

INWARD OPENING OVEN INTAKE FOR GAS CHROMATOGRAPHIC OVEN

1 **Technical Field**

2 The technical field relates to a gas chromatographic oven, and, in particular, to
3 oven cooling efficiency.

4 **Background**

5 Gas chromatography (GC) is a physical method for the separation, identification,
6 and quantification of chemical compounds. A sample mixture is injected into a flowing
7 neutral carrier stream and the combination flows through a tube or chromatographic
8 column. The inner surface of the column is coated or packed with a stationary phase. As
9 the sample mixture and carrier stream flow through the column, the components within
10 the mixture are retained by the stationary phase to varying degrees depending on the
11 relative volatility of the individual components and on their respective affinities for the
12 stationary phase. Different chemical compounds are retained for different times by the
13 stationary phase. When the individual mixture components are released into the carrier
14 stream by the stationary phase, the components are swept towards the column outlet to be
15 detected and measured by a detector. The specific compounds in the components of the
16 mixture can be identified and their relative concentrations determined by measuring peak
17 retention times and peak areas respectively.

18 In the push for faster chromatography, the trend continues to be towards smaller,
19 less thermally massive ovens. The oven temperature needs to be controlled at a specific
20 rate. After one sample run is completed, the oven generally needs to be cooled down to
21 the start temperature before another sample can be analyzed. To achieve faster cycle time
22 and higher sample throughput, it is desirable to minimize the oven cool-down time. One
23 method is to optimize the airflow into and within the oven both during heating and
24 cooling. Engineering the airflow patterns is a challenge as visualization techniques are
25 few and expensive. Most of the advances have been a result of trial and error.

26 Current solutions either passively or actively influence the airflow patterns into
27 and within a GC oven during oven cool-down. For example, some GC ovens passively
28 introduce fresh air into the oven by having the end of the intake duct situated directly
29 behind the oven's stirring fan in a low-pressure region. This low-pressure region works
30 to draw air in through the intake duct. With smaller GC ovens, a more active approach
31 has been attempted to place the intake opposite the oven's stirring fan and to locate an
32 additional boxer fan on the intake duct to force fresh air into the oven. A tradeoff exists

1 in this design, however, because the boxer fan's placement forces the boxer fan to work
2 against the oven's stirring fan. As a result, the stirring fan must be operated at only a
3 percentage of its full power in order to not overwhelm the boxer fan during cooling.

4 **Summary**

5 An air intake for an oven having an inside and an outside includes an intake duct;
6 and a movable intake flap. The moveable intake flap is operably connected to the intake
7 duct and has a closed and an open orientation. The intake flap is positioned so that when
8 the intake flap is in the open orientation, more of the intake flap is located on the inside of
9 the oven than on the outside of the oven. In the open orientation, the intake flap opens
10 into the oven at a flap angle that creates a low-pressure region to draw airflow into the
11 oven from the intake duct.

12 A method for providing an inward opening oven intake for a gas chromatographic
13 oven includes assessing airflow inside an oven, determining an advantageous location for
14 an intake flap, and placing the intake flap at the advantageous location near a bottom of
15 the oven. The method further includes determining a flap angle of an opening of the
16 intake flap, and enabling the intake flap to open into the oven at the flap angle to create a
17 low-pressure region to assist in drawing airflow into the oven from one or more cooling
18 fans.

19 A corresponding system for providing an inward opening oven intake for a gas
20 chromatographic oven includes an intake duct positioned beneath an oven. The intake
21 duct having one or more cooling fans. The system further includes an intake flap
22 positioned at an advantageous location near a bottom of the oven. The intake flap opens
23 into the oven at a flap angle to direct an airflow originating from the one or more cooling
24 fans to approximate a direction of a second airflow originating from stirring fans inside
25 the oven.

26 **Description of the Drawings**

27 The preferred embodiments of a system and method for providing an inward
28 opening oven intake for a gas chromatographic oven will be described in detail with
29 reference to the following figures, in which like numerals refer to like elements, and
30 wherein:

31 Figure 1 illustrates an exemplary inward opening oven intake that includes an
32 intake duct and an inward opening intake flap that opens into a gas chromatographic (GC)
33 oven;

1 Figure 2 illustrates a cutaway side view of the exemplary inward opening oven
2 intake of Figure 1 with the intake closed;

3 Figure 3 illustrates a cutaway side view of the exemplary inward opening oven
4 intake of Figure 1 with the intake open;

5 Figure 4 illustrates a front view of the exemplary inward opening oven intake of
6 Figure 1; and

7 Figure 5 is a flow chart illustrating an exemplary method for providing an inward
8 opening oven intake for a GC oven.

9 **Detailed Description**

10 An inward opening oven intake for a gas chromatographic (GC) oven includes an
11 inward opening intake flap that opens into the GC oven near the bottom of the GC oven.
12 Opening at a flap angle, the inward opening intake flap creates a low-pressure region to
13 draw a large amount of airflow into the GC oven during cool-down. In addition, the
14 inward opening oven intake manipulates the airflow within the GC oven to more
15 efficiently draw heat away from the oven walls. This greater efficiency allows for faster
16 cycle time and higher sample throughput.

17 Figure 1 illustrates an exemplary inward opening oven intake 100 that includes an
18 intake duct 120 and an inward opening intake flap 110 that opens into a GC oven 210
19 (shown in Figures 2 and 3). The intake duct 120 shown in Figure 1 has a cross-section of
20 approximately 165mm x 80mm to accommodate 80mm intake fans 140 (shown in Figures
21 2 and 3) that converges to a cross-section of 165mm x 35mm to be minimally obtrusive to
22 the oven 210. However, other shapes of intake duct can also be employed. The inward
23 opening intake flap 110 shown in Figure 1 has a long flat rectangular shape,
24 approximately 165mm x 35mm. However, other shapes of intake flap may be employed,
25 such as a curved airfoil design. As shown in Figure 1, the inward opening intake flap 110
26 opens into the GC oven 210. Generally, having a large obtrusive flap opening completely
27 into the oven may cause disruption of airflow inside the GC oven 210 and is avoided.
28 The inward opening intake flap 110 of Figure 1 is long and thin, and only opens slightly
29 into the GC oven 210 at a flap angle 150 (shown in Figure 3). The shape, size and design
30 of the inward opening intake flap 110 reduce interference with the airflow inside the GC
31 oven 210.

32 Figure 2 illustrates a cutaway side view of the exemplary inward opening oven
33 intake 100 when the intake is closed. The inward opening intake flap 110 may open into
34 the GC oven 210 at the bottom of the GC oven (at line 160). The GC oven 210 may

1 include stirring fans 220 that provide airflow 250 inside the GC oven 210. The intake
2 duct 120 may be located at the bottom of the GC oven 210 to fit smaller sized ovens. For
3 example, this intake duct 120 is centered on the bottom of the oven 210 located about
4 5mm from the oven door. The intake duct 120 may be made of stainless steel or
5 aluminum material with either a uniform cross-section or a non-uniform cross-section.

6 The intake duct 120 may include one or more cooling fans 140. During cool-
7 down, the inward opening intake flap 110 snaps open to allow air to flow from the
8 cooling fans 140 through the intake duct 120 into the GC oven 210. The air then exhausts
9 from the GC 210 oven into open space through an exhaust duct 230 (shown closed in
10 Figure 2). The inward opening intake flap 110 is closed in Figure 2 but may open at a
11 flap angle 150 (shown in Figure 3) to approximate airflow 250 within the GC oven 210
12 such that air is more efficiently drawn out of the intake duct 120 into the GC oven 210.

13 Figure 3 illustrates a cutaway side view of the exemplary inward opening oven
14 intake 100 when the intake is open. During cool-down, the inward opening intake flap
15 110 snaps open into the GC oven 210 at a flap angle 150 generally between 0° and 90°.
16 The cooling fans 140 in operation push fresh air upwards past the inward opening intake
17 flap 110 into the GC oven 210.

18 The inward opening intake flap 110, opening at a flap angle 150, may direct the
19 airflow 350 being introduced by the cooling fans 140 of the oven intake 100 to
20 approximate the direction of the airflow 250 from the oven's stirring fans 220 to facilitate
21 insertion of this cool flow 350. Also, the high velocity flow from the oven's stirring fans
22 220 flowing over the inward opening intake flap 110 creates a low-pressure region on top
23 of the inward opening intake flap 110. The low-pressure region tends to draw additional
24 airflow from other areas, such as from the oven intake 100, into the GC oven 210. This
25 principle is referred to as Bernoulli's principle. As a result, in addition to the cooling fans
26 140 working to force air 350 into the GC oven 210, the airflow 250 inside the GC oven
27 210 creates a pressure to assist.

28 The flap opening angle 150 may be determined based on the angle of the airflow
29 250 originating from the stirring fans 220 flowing past the region where the inward
30 opening intake flap 110 is located. To avoid disrupting the airflow 250 inside the GC
31 oven 210, the flap angle 150 preferably approximates the angle of the airflow 250 flowing
32 past the region where the inward opening intake flap 110 is located. A series of
33 experiments with the inward opening intake flap 110 opening at different angles may be

1 run to assess the airflow 250 inside any given GC oven 210 and to determine an
2 advantageous location for the inward opening intake flap 110 and a flap angle 150 that
3 results in the fastest cool-down. A flap angle 150 is usually specific to each oven design
4 and may depend on the size and shape of the GC oven 210, the speed and location of the
5 stirring fans 220, and the speed of the cooling fans 140 amongst several other parameters.
6 The range of the flap angle may be between 0° and 90°. Some examples of the flap angle
7 150 are 30°, 40°, 50°, and 60°. For example, a 30° flap angle may be used for a small fast
8 GC oven 210 without significantly disturbing the airflow 250 inside the GC oven 210 yet
9 resulting in a faster cool-down.

10 Referring to Figure 3, the oven intake 100 may optionally include a second flap
11 115. When the inward opening intake flap 110 opens at the flap angle 150, the second
12 flap 115 may be positioned along the direction of the airflow 350 flowing from the
13 cooling fans 140 to the GC oven 210. When the inward opening intake flap 110 snaps
14 shut, the second flap 115 may swing 90° to provide a layer of air insulation 170 (shown in
15 Figure 2) between the GC oven 210 and the cooling fans 140, thus, insulating the cooling
16 fans 140 from the hot oven 210.

17 The second flap may be connected to the inward opening intake flap 110 through
18 a linkage system (not shown), such as a four-bar linkage system. A four-bar linkage
19 system is a mechanism that consists exclusively of “revolute” joints. The linkage system
20 may be controlled by a control device, such as a solenoid (shown in Figure 4). The
21 control device may open the flaps 110, 115 at different pre-defined angles. For example,
22 the linkage system may drive the second flap 115 90° and the inward opening intake flap
23 a flap angle 150 less than 90°. Other methods of moving the flaps 110, 115, such as a
24 stepper motor, a proportional solenoid, or other types of proportional control device, may
25 be employed. The proportional control device may allow the flaps 110, 115 to close more
26 softly and therefore not upset the thermal equilibrium in the oven as much. In the event
27 of unexpected power loss, the control device may function as a switch and cause the flaps
28 110, 115 to automatically snap shut to keep the oven and the cooling fans separate during
29 the power loss. Alternatively, the second flap 115 may have its own control device,
30 mechanical or otherwise.

31 Figure 4 illustrates a front view of the exemplary inward opening oven intake 100
32 shown with the intake duct 120 and the inward opening intake flap 110. The inward
33 opening intake flap 110 opens at a flap angle 150 into the GC oven 210 near the bottom

1 of the GC oven (line 160). The oven intake 100 also includes a solenoid 130 with spring
2 return to be used as a switch or control for the inward opening intake flap 110. As noted
3 above, the solenoid 130 drives the mechanics connected to the inward opening intake flap
4 110 to adjust the opening angle of the inward opening intake flap 110.

5 Figure 5 is a flow chart illustrating an exemplary method for providing an inward
6 opening oven intake for a GC oven 210. After assessing the airflow 250 inside the GC
7 oven 210 (block 510), the method determines an advantageous location for the inward
8 opening intake flap 110 in the GC oven 210 (block 520). The method places the inward
9 opening intake flap 110 at the advantageous location near the bottom of the GC oven 210
10 (block 530). Next, the method determines a flap opening angle 150 of the inward
11 opening intake flap 110 based on the angle of the airflow 250 in the GC oven 210 flowing
12 past the region where the inward opening intake flap 110 is located (block 540). The
13 method enables the inward opening intake flap 110 to open into the GC oven 210 at a flap
14 angle 150 to maximize the airflow flowing into the GC oven 210 from the opening (block
15 550). Cooling fans 140 may be used to produce the airflow. The method may also
16 provide a control device to control the flap angle 150 (block 560). One embodiment is a
17 solenoid 130 that controls and adjusts the opening angle of the inward opening intake flap
18 110. The method may also provide a second flap 115 to create a layer of air insulation
19 170 between the GC oven 210 and the cooling fans 140 (block 570).

20 While the system and method for providing an inward opening oven intake for a
21 GC oven have been described in connection with an exemplary embodiment, those skilled
22 in the art will understand that many modifications in light of these teachings are possible,
23 and this application is intended to cover variations thereof.